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ABSTRACT

The study used meta-analysis techniques to examine the effectiveness of intervention strategies for children with cerebral palsy. An examination of existing literature on meta-analysis revealed that techniques are available to accommodate a wide variety of research designs and data. Next, the percentage of studies purporting to address an intervention strategy which actually provided data usable in the meta-analysis was found to be 48% (31 of 65 studies retrieved). The need for investigation to provide adequate outcome data when reporting results was stressed. It was concluded that results were insufficient to draw conclusions regarding interventions for children with cerebral palsy. The final research question found low correlations among such factors as research design, sample size, method of calculation, and year of publication with the obtained effect size. Five pages of references conclude the report. (CL)

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# Cerebral Palsy: The Meta-Analysis of Selected Interventions

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# Cerebral Palsy:
# The Meta-Analysis of Selected Interventions

## Introduction

### Statement of the Problem

The provision of educational services to special populations typically involves the development and use of unique curricula, materials, and techniques and raises the question of the effectiveness of these procedures (Kavale & Glass, 1982). Nowhere are these issues more important than in the case of interventions with cerebral palsied children who cover "the entire spectrum of developmental disabilities - mental retardation, learning disabilities, seizure disorders, and motor deficits" (Vining, Accardo, Rubenstein, Farrell, & Roizen, 1976, p. 643).

Therapeutic interventions for children with cerebral palsy are aimed at improving mobility, communication, and educational performance. They vary widely in their emphases but commonly include neuromuscular facilitation and other physical and occupational therapy approaches, surgery, positioning and adaptive devices, biofeedback, and medication (Lord, 1984). Faced with this wide array of research findings, investigators conducting traditional literature reviews find that many questions remain unanswered. Not only is there a wide range of interventions and outcome variables reported in the literature; but as Kavale and Glass (1982)

have indicated with respect to special education in general, findings are often conflicting and variable.

It is within such a framework that meta-analysis is appropriately employed. Meta-analysis is a relatively recent development in the integration of research findings. The term "meta-analysis" was coined by Glass (1976) who used it to refer to the "analysis of analyses." (p. 3). It employs quantitative methods in order to provide a systematic means of synthesizing research findings and to answer general questions concerning the results of a large body of research literature on a specified topic.

Purpose of the Study

The purpose of this study was twofold. It stemmed in part from this researcher's interest in further developing research skills through the application of meta-analysis. Thus, the process of meta-analysis was examined, and formulae for computation of effect sizes under varying conditions were applied.

An equally important function of the study was the systematic examination of data regarding the interventions currently employed for children with cerebral palsy. Of particular interest were findings that might indicate which intervention strategies have merit and whether and under what conditions a given treatment is more appropriate than others.

The study was also intended to identify interventions requiring further empirical study.

## Research Questions

Given the general purposes of the study, the following research questions were developed.

1. Are appropriate meta-analysis techniques available for use in integrating literature related to interventions with special populations (i.e., children with cerebral palsy)? In particular, can meta-analytic techniques accommodate control-group-only and single-subject designs?

2. To what extent does the existing literature on interventions for children with cerebral palsy provide data needed for carrying out a meta-analysis?

3. Does the meta-analysis of research on interventions for children with cerebral palsy indicate the relative merits of the various treatments?

4. Do other factors (such as research design, sample size, method of calculation, year of publication) have a bearing on the obtained effect size?

## Methods

The general approach to conducting this meta-analysis was the one suggested by Kavale and Glass (1981). Studies to be included in the meta-analysis were located and retrieved from a variety of sources. Literature searches were conducted in ERIC, Current Index to Journals in Education,

Psychological Abstracts, Dissertation Abstracts, Index Medicus, and a Medline computer search. In addition, traditional literature reviews were consulted to identify further research studies. Finally, several unpublished studies were made available for possible inclusion in the meta-analysis. For each of the studies finally included in the meta-analysis, information was retrieved and recorded on a data collection sheet, an example of which is found in Appendix A.

The metric selected for use in the meta-analysis was effect size. Effect sizes were computed or estimated using a variety of formulae suggested in the literature. The formula employed depended in each case on the nature of the data available in a given study.

In general, the effect size is calculated by dividing the difference between experimental and control group means by the within-group standard deviation (Hunter, Schmidt, & Jackson, 1982) as given by the following formula:

$$d = \frac{\bar{Y}_e - \bar{Y}_c}{S}$$

McGaw and Glass (1980) addressed the problem of using final status scores to obtain mean differences. One difficulty arises when such scores are not available, as when gain scores are used. Another problem is encountered when there are pretreatment group differences. The authors

stated, "The use of gain scores, residual scores, and covariance adjustments when there are preexperimental group differences is an attempt to render the groups comparable." (p. 328). They have offered formulae for calculating mean differences with each of these three types of scores. When pretreatment differences do not exist, mean differences should be the same regardless of the scale used for computation; but where such differences do exist, the formulae will correct for them. Thus, it would seem that McGaw and Glass are recommending the routine use of these formulae rather than the traditional formula which uses the final status score. The following are formulae given by McGaw and Glass:

For raw gain scores,

$$\overline{G_t} - \overline{G_c} = (\overline{Y_t} - \overline{Y_c}) - (\overline{X_t} - \overline{X_c})$$

For residual gains,

$$(\overline{G_t} - \overline{G_c}) = (\overline{g_t} - \overline{g_c}) - (1 - b_{yx})(\overline{X_t} - \overline{X_c})$$

For covariance adjustments,

$$(\overline{G_t} - \overline{G_c}) = (\overline{Y_t} - \overline{Y_c}) - (1 - b_{yx})(\overline{X_t} - \overline{X_c})$$

In these formulae, $G_t$ and $G_c$ represent raw gain scores for the treatment and control groups respectively, $Y_t$ and $Y_c$ represent posttest scores of these groups, $X_t$ and $X_c$ represent pretest scores, $g_t$ and $g_c$ represent residual gain scores, and $b_{yx}$ is the pooled within-groups estimate of the regression of final status on initial status.

The final status score standard deviation was advocated as the measure of choice for use in the denominator in order to arrive at the effect size (McGaw & Glass, 1980). As Glass (1977) pointed out, the control group standard deviation is preferred when within-group standard deviations are not homogeneous. Furthermore, the use of standard deviations derived from any of the other metrics such as raw gains, residual gains, and covariance adjustments would all yield different effect sizes. The recommendation made by McGaw and Glass (1980) standardizes the mean differences on the basis of final status scores.

A number of other instances arise in which it is necessary to use altered formulae for calculating the control group standard deviation or for estimating a value when a direct measure is unobtainable. The situations discussed by McGaw and Glass (1980) include those in which (1) one or more treatment conditions are present but there is no control group, (2) final status scores have been adjusted, (3) factorial designs are employed with two-way or higher interactions, and (4) repeated measures analyses are used. Formulae appropriate in each of these situations were given by the authors and were employed as appropriate in the present study.

Holmes (1984) provided several methods for computing or estimating effect sizes in the absence of group means and standard deviations. A number of alternatives exist

depending on the information given in a study. For instance, an effect size can be estimated when a t value, the degrees of freedom, and the size of the experimental group mean relative to the control group mean are known. In the case of an independcnt t-test and under the assumption of equal size groups and homogeneous variances, the formula is

$$ES = \frac{2t}{\sqrt{N}}$$

where t is the obtained t value and N is the sample size. A correction when the test is a dependent t-test yields the following formula:

$$ES = \frac{2t}{\sqrt{N}} \cdot \sqrt{1-r}$$

where r is the correlation between the outcome variable and the matching variable. When the t value is given and group sizes are known but unequal and homogeneity of variance is assumed, the obtained t value can be used in the formula below to estimate the effect size:

$$ES = t\sqrt{\frac{1}{n} + \frac{1}{n}}$$

where n and n are the sample sizes of the experimental and control groups.When the obtained t value is not known but the significance level is given, the same formula can be used to

estimate a minimum effect size by substituting the minimum *t* value needed for significance.

Effect sizes can also be estimated under a variety of other conditions, such as when (1) a critical F value is reported when 2 or more groups are compared, (2) an analysis of variance summary table is provided, (3) group sizes and the proportions of the groups possessing an attribute are reported, and (4) group sizes and nonparametric statistics (such as chi-square) are reported. Holmes (1984) has offered conversion or estimation formulae in each of these instances. Again, these formulae were employed as appropriate in the study.

Glass, McGaw, and Smith (1981) discussed the use of probit transformation which is an attempt to recover underlying metric information when only dichotomous data are available. They provided a table on page 139 which allows for the quick determination of effect size when proportions for experimental and control conditions are available.

An additional problem in effect size estimation is posed when studies under consideration include single-subject designs. Such a situation occurs frequently in studies of interventions for children with cerebral palsy. Gingerich (1984) has applied meta-analysis techniques in the aggregation of single-subject studies in order to provide stronger support for conclusions regarding treatments. Thus, single-subject designs might appropriately be included in

meta-analyses through the aggregation of like studies or several single-subject outcomes in a given study in order to calculate effect sizes.

An alternative method for determining effect size in single-subject studies was employed by Prochnow-LaGrow (1984). She described her computational procedure in this way: "ES was calculated by dividing the mean change from baseline to intervention by intrasubject variability evidenced in baseline." (p. 1077). Of course, this procedure would be appropriate only when multiple baseline measures are available.

Rosenthal (1983) offered the following formula for computing effect size when a correlation coefficient is given:

$$d = \frac{2r}{\sqrt{1 - r^2}}$$

Rosenthal also offered several formulae for estimating r.

## Results and Conclusions

After reviewing over 100 studies or abstracts, 65 studies were obtained which addressed an intervention strategy for children with cerebral palsy. Of these, 34 had to be rejected because they did not report sufficient data for the calculation of effect size. The remaining 31 studies were included in the meta-analysis. The citations for these studies follow the references.It should be noted at this

point that the literature retrieval was not complete due to temporal and monetary constraints. Thus, the available research, to the extent that it is not representative of the larger body of literature, may lead to bias in the meta-analysis results.

Included among the 31 studies were 6 single-subject designs, 14 treatment-group-only designs, and 11 experimental-control group designs (6 of which involved random assignment). Sample sizes ranged from 1 to 124 with a mean sample size of 23.48. A total of 96 effect sizes was calculated for the 31 studies. The mean effect size was .78 with a standard deviation of 1.5974. An average effect size was computed for each study (or each independent subject in a study) yielding 44 effect sizes. These were averaged across all 31 studies, and a mean effect size of .8125 was computed with a standard deviation of 1.5212.

Correlations were computed to determine if any relationship existed between effect size and selected study features. These correlations are shown in Table 1.

Table 1

Correlations of Effect Size with Selected Study Features

| Study Feature | r |
|---|---|
| Sample Size | -.04 |
| Study Design | .03 |
| Computational Method | -.03 |
| Year of Study | -.16 |

Studies included in the meta-analysis were classified according to the type of intervention addressed in the

research. Means and standard deviations of effect sizes were calculated for these classifications. The results are shown in Table 2.

Table 2

Effect Size X and SD by Intervention

| Variable | # of Studies | # of ES | X ES | SD ES |
|---|---|---|---|---|
| Positioning/ Devices | 3 | 5 | .75 | 0.4312 |
| Behavioral/ Biofeedback | 6 | 26 | 1.95 | 1.8210 |
| DPM | 2 | 5 | - .23 | 0.7472 |
| NDT | 3 | 12 | .14 | 1.5600 |
| Vestibular Stimulation | 2 | 9 | 1.10 | 1.1734 |
| Other PT/OT | 8 | 16 | .60 | 0.8352 |
| Chronic Cerebellar Stim | 2 | 12 | -.80 | 1.1100 |
| Wrapping | 1 | 4 | .99 | 0.1720 |
| Femoral Osteotomy | 1 | 3 | .15 | 0.1543 |
| Medication | 1 | 1 | 2.19 | ----- |
| Electrical Stim | 1 | 1 | 2.56 | ----- |
| Blacklight | 1 | 1 | .78 | ----- |

Means and standard deviations of effect sizes were also calculated separately for each intervention as it related to a given outcome variable. The results of these calculations are shown in Table 3.

Table 3

Mean and Standard Deviation of Effect Sizes
by Intervention and Outcome Variable

| Variable | # of Studies | # of ES | X ES | SD ES |
|---|---|---|---|---|
| Head Control | | | | |
| Positioning | 1 | 2 | 1.21 | 0.2750 |
| Biofeedback | 2 | 9 | .67 | 1.1665 |
| Reducing Spasticity/ Involvement | | | | |
| Positioning | 1 | 2 | .58 | 0.0150 |
| DPM | 2 | 2 | -.31 | 0.8800 |
| NDT | 1 | 1 | 1.09 | ----- |
| CCS | 1 | 1 | -.85 | ----- |
| Electrical Stim | 1 | 1 | 2.56 | ----- |
| Speech/Language | | | | |
| Positioning | 1 | 1 | .20 | ----- |
| NDT | 1 | 1 | .32 | ----- |
| CCS | 1 | 3 | .92 | 0.2029 |
| Reducing Drooling | | | | |
| Biofeedback | 2 | 4 | 2.28 | 0.7397 |
| Feeding | | | | |
| Biofeedback | 1 | 3 | 1.78 | 0.5604 |
| Walking/Gait | | | | |
| Biofeedback | 10 | 10 | 3.02 | 2.1034 |
| OT/PT | 1 | 3 | .05 | 0.0283 |
| CSS | 1 | 2 | .68 | 0.1750 |
| Motor Dev/Imprvmt | | | | |
| DPM | 1 | 1 | -1.04 | ----- |
| NDT | 3 | 8 | - .32 | 1.6744 |
| Vestibular Stim | 2 | 8 | 1.22 | 1.1914 |
| PT/OT | 7 | 7 | .52 | 0.6085 |
| CSS | 1 | 6 | -1.66 | 0.3848 |
| Medication | 1 | 1 | 2.19 | ----- |
| Mental Development | | | | |
| DPM | 1 | 1 | - .37 | ----- |
| NDT | 1 | 1 | 2.07 | ----- |
| Vestibular Stim | 1 | 1 | .14 | ----- |
| Personal/Social | | | | |
| NDT | 1 | 1 | .77 | ----- |
| PT/OT | 1 | 1 | .55 | ----- |
| Range of Motion | | | | |
| Surgery | 1 | 3 | .15 | 0.1543 |
| Wrapping | 1 | 4 | .97 | 0.1530 |
| Breathing | | | | |
| PT/OT | 1 | 2 | 1.59 | 1.6600 |

The interpretation of effect size is straightforward and quite similar to interpretation of a z-score (Kavale & Glass,

1981). For example, an effect size of 1.00 "would indicate that a subject at the 50th percentile of the control group would be expected to rise to the 84th percentile of the control group" (p. 533) following treatment. Such an effect size suggests that the treatment group has performed at a level that is one standard deviation above the control group.

Wampler (1982) among others has cited the effect size values recommended by Cohen (1977) in judging the magnitude of effect sizes. Using these criteria, effect sizes of .35 and below are considered small, those between .36 and .65 are moderate, and those above .65 are viewed as large. Kavale and Glass (1982), however, have indicated that effect sizes must be judged within the context of circumstances which may vary from setting to setting.

The highest effect sizes in the present study, when examining intervention strategy without regard for outcome variable type, were found in electrical stimulation, medication, behavioral and biofeedback, and vestibular stimulation studies. When outcome variables are considered, neurodevelopmental therapy (NDT) and physical and occupational therapy fair well for selected outcomes. Wampler (1982) has suggested, however, that at least six effect sizes are needed in order for results to be considered conclusive. Thus, conclusions based on results of the present study are quite limited.

In addition to the small number of effect sizes for a given intervention and outcome, other issues arise in interpretation of results. Nonindependence of effect sizes and variation in the quality of research, two criticisms lodged against meta-analysis (Glass, 1982), can be said to exist in the present analysis. Along with the issue of the biasing effect of differing sample sizes, the problem of nonindependence can be addressed through statistical procedures (Glass, 1977; Glass, McGaw, & Smith, 1981; Hedges, 1983; Rosenthal & Rubin, 1982).

## Conclusions and Recommendations

In response to the first research question, an examination of existing literature on meta-analysis revealed that techniques are available the accommodate a wide variety of research designs and data. Single-subject designs, common in special education research, can be included in meta-analyses if appropriate data are made available.

The second research question was answered by calculating the percentage of studies, among those purporting to address an intervention strategy, which actually provided data usable in the meta-analysis. Among the 65 studies retrieved, only 31 (48%) contained even minimal data. This finding emphasizes the need for investigators conducting primary research to provide adequate outcome data when reporting results.

The recovery of research studies was admittedly not exhaustive in the present meta-analysis. Present results are insufficient to draw conclusions regarding interventions for children with cerebral palsy. It is apparent that the majority of interventions require further empirical study. Many of the retrieved studies provided inadequate information with regard to sample characteristics such as age and severity of handicapping condition. Knowledge of these factors would offer greater precision in future meta-analyses which, in addition to including a greater number of studies, might more appropriately focus either on a particular intervention category (i.e. biofeedback or physical and occupational therapy) or on a particular set of outcomes (such as motor development and improvement of motoric function).

The final research question was answered through the computation of appropriate correlations which revealed very low correlations in every instance.

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# APPENDIX A

## DATA COLLECTION SHEET

Citation

Sample Size

Sample Characteristics

Treatment Characteristics

Groups

Dependent Variables

Research Design

Group X's and SD's

Effect Size Computation